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THE PROPOSED THINNING OF THE 11 YEAR OLD PROGENY TEST PLANTATION FROM THE 1929 NURSERY

By Lloyd Austin, November 20, 1939

In endeavoring to decide whether or not the 11-year-old progeny test plantation should be thinned in the near future it is important to consider rather fully the history of this plantation, what purposes it was designed to serve, and such other factors as may have a bearing on the problem.

The principal objectives of the nursery and plantation stages of the experiment were naturally outlined in full when these stages were initiated. However, as this is the first comprehensive long-time experiment ever undertaken with seed from large numbers of individual tagged seed-trees scattered over a wide territory, the methods of procedure have necessarily evolved gradually over a long period of time. There are quite numerous reports, memoranda and other records covering different phases of the experiment, but unfortunately there has been no time in recent years to bring all of this material together into a complete treatise from which one unfamiliar with the work can gain a full understanding of all phases of the investigation to date. There is no opportunity now for preparing an exhaustive treatise of this kind, but I will endeavor to summarize sufficient material about this experiment to enable those interested to understand the proposed thinning.

As Dunning's comments on this thinning have already been sent to the staff, it may be well for me to give some consideration in my discussion to the matters covered in his memorandum. I regret that in the limited time available when Dunning was here it was possible to give him only a partial understanding of the nature of the plant material included in this plantation, and comparatively little concerning the priorities of the various objectives. He has listed most of the purposes of the test, but unfortunately (since he has given a great deal of careful thought to the matter) the majority of his discussion is based on entirely incorrect assumptions as to the relative importance of the different comparisons. Most serious is his supposition that this plantation was set out, as was the 1937 plantation, primarily to compare the progenies of different individual seed-trees or mother trees. As will be explained more fully subsequently, such comparisons are, in general, not of any appreciable value in this particular plantation, for the great majority of the progenies are from entirely different localities and regions. Hence one must compare mainly representatives of different races or strains, and not the different progenies within these.

In the nursery stage of the 1929 progeny test (containing four replications of each of 765 progenies of P. ponderosa, P.p. scopulorum and P. jeffreyi) there were two major objectives, namely: (1) a growth comparison of geographical races, and (2) a comparison by means of their progenies, of the relative value of different seed-trees growing in the same field plot or restricted locality. For the plantation stage of the test it was considered desirable to give nearly all of the emphasis to the first of these objectives, since it was found that it would not be possible to serve both adequately with the greatly reduced numbers that could be accommodated in the plantation with the land available.

It was felt at that time that future progeny tests would probably be much more localized in their seed sources, and that they would, therefore, be better adapted than the 1929 experiment to plantation studies of the relative growth of progenies from different seed-trees in the same locality. Hence it was considered that the 1929 test would be most useful if designed to serve primarily as a comparison of the growth rates of geographical races and as the most complete existing collection of these for breeding purposes. In order to provide plantation samples from nearly all of the 57 counties represented in the nursery test, it was necessary to use, in most cases, only one, two or three progenies per county, instead of the five to twenty or more that occurred in the nursery. Thus the number of progenies per county necessarily became so small in most cases that little can be expected from plantation comparisons of different progenies of the same general seed origin. In this way the emphasis purposely was placed, at the time this plantation was made, on a comparison of different origins, one with another, and not on seed-tree variation within any particular locality.

The plantation plan not only provided for the above concentration of objectives, but also provided very specifically for maintaining these objectives even after the thinning that was scheduled to take place when the trees reached 10 years of age.

The plan of growing the progenies intermingled, instead of with isolation strips on all four sides of each plot, was adopted in the 1929 plantation, not because it was desired to provide comparisons under competition, but largely because it required much less land. With the limited amount of cleared land available at that time it seemed better not to allow space for isolation strips, but to arrange to take care of the matter of unequal competition by a definitely planned thinning operation to be carried out before competition became serious. Accordingly, in designing the plantation the progenies and races that it was desired to test and compare over a long period of years were first placed in the permanent rows, and then the duplicates

and other less important types, to be tested for only about ten years, were placed in the alternate rows that were to be thinned out. As Dunning points out, the original map, made before the plantation was set out, shows by yellow shading, the provision for thinning by regularly removing every other row over the entire plantation.

It would appear that, as long as the thinning is done early enough, the slight crowding before thinning will not be appreciably more serious than that which almost always occurs in the seedbed before the stock is dug. By the time the seedlings in the nursery reach the age of 2 years an unequal competitive influence is beginning to take effect. But the outplanting of the seedlings is considered to remove this and to supply equal conditions once more. Likewise, the proposed thinning will remove the crowding effect that is commencing and will largely restore equal growing conditions. It seems important, however, to thin this plantation soon, as otherwise the vigorous progenies will crowd out the small ones so seriously that the latter may become permanently stunted.

It is worthy of note that the technique used in handling this stock and the care given it has been such that the irregular conditions that are commonly encountered in experimental plantations due to the death of trees during the first few years are almost entirely lacking in this planting. At the age of eleven years about 99% of the original trees are still growing and the few that have died have nearly all been replanted. However, the replants are used merely to equalize competition, and are not included in the averages.

It is obviously true that following the thinning out of every other row (in only one direction) the trees will not be equally spaced in all directions. But, from the point of view of statistically measuring the inherent differences between different plots of trees, this is a decided advantage, rather than a disadvantage. Yates strongly recommends that plants of the same progeny be spaced closer together than plants of different progenies. We used this principle in the large 1937 progeny test nursery (seedlings 3" apart in rows 6" apart) and a similar condition will exist in the 1929 plantation after it is thinned. The trees of any one progeny will be 7.5' apart, and there will be 15' spaces between progenies.

Although desirable, it is not necessary to provide conditions that will allow for equal branch development on all four sides of the trees, for all progenies and races will be subjected to approximately the same conditions and thus their relative branch development will be comparable. A very similar condition exists in our latest design used for the 1937 plantation, and is a condition that is unavoidable in designs that provide the isolation strips required by modern statistical methods.

In this connection it should be kept in mind that one of the purposes of the test is to study the inheritance of various types of branching. Seed was purposely gathered from quite a number of trees having rather unusual branching habits. Since trees in dense stands very seldom bear sufficient seeds, nearly all of our seed-trees are open-grown ones. Thus it develops that if we are to be able to find in the progenies the particular branching characters that are similar to those of the different parents, we must provide, on at least two sides of the trees, reasonably open growing conditions. Under heavy competition on all four sides, branch development is much subdued, and there is hardly any opportunity for the expression of the different hereditary tendencies to branch. We have found this to be strikingly true in the nursery, and it is equally true in the plantation.

Also, it seems quite important to endeavor to develop strains that will produce relatively clear lumber without the use of the excessive crowding that is considered necessary with the present strains of trees. We should not make the mistake of basing all of our concepts of the future utilization of new strains on the practices employed today. With improved types available, practices will change according to the nature of the improvements. Forms with early-shedding branches could be planted farther apart, thus reducing planting costs and avoiding the stagnation in growth due to heavy competition. This would eliminate Nature's wasteful process that requires the loss of great numbers of trees through suppression. The thinning of the 1929 plantation as planned will make possible the selection of the desirable strains and progenies of ponderosa pine that, like slash pine, tend to drop their branches at an early age even when there is relatively little competition. At the same time, the trees will be close together within the rows or plots, and the ability of the different types to shed branches under competition can also be judged.

Since this plantation is to be chiefly a long-time study of the geographical or climatic races of ponderosa pine and related forms, it is pertinent to inquire into the extent to which these different races have been sampled and will be represented in the plantation after thinning. A table is appended to this memorandum that summarizes the representation of P. ponderosa, P.p. scopulorum and P. jeffreyi in the nursery, in the plantation before thinning, and in the plantation after thinning. It is very apparent from this tabulation that the design utilized for this plantation provides for preserving after thinning some representation of about three-fourths or more of the states, counties and field plots included in the plantation. When the thinning has been completed there will remain samples of 59 field plots scattered over 42 different counties in 13 states. Even in this somewhat reduced form, this still represents the most complete sampling ever undertaken of the races of P. ponderosa and related forms.

The preservation after thinning of this relatively complete sample of the numerous seed origins is possible only because the plantation was carefully designed with this in view. Had the matter been left to chance, the removal of half of the trees would remove about half of the geographical sources, instead of only one fourth of them.

It goes without saying that the samples from any one locality are not exhaustive and cannot be expected to represent the full range of variation that might be encountered in trees of that seed origin. However, this is a limitation common to practically all tests covering wide geographical areas. Ordinarily time and funds do not permit the combination of extensive and intensive investigations. The 1929 test is of the extensive type. The 1937 test is of the intensive type, aimed to bring out the full natural variation in a limited locality, the El Dorado transect of the Sierra. Together, the two tests complement each other and provide a remarkable demonstration of the nature of the variation that occurs within ponderosa pine.

As it is too early to characterize and definitely delimit specific races of ponderosa pine, it seems best for the present to make the geographical comparisons arbitrarily on the basis of field plots and counties, or, as Weidman has suggested, we may wish to use, as far as they are applicable, the corresponding national forests in naming our seed origins. It will be necessary, in presenting any data pertaining to these, to make it clear that it is not considered that each sample is fully representative of all forms growing throughout the county or national forest named. However, the exact elevation and location is known for each field plot, and it will be best to consider the samples as representing the ponderosa pine that is native to those particular localities and elevations.

The number of trees that will remain in the plantation to represent the 59 different field plots is shown in the appended table. It will be seen that 8 of them will be represented by 18 or more trees (3 replications), 18 of them by 12 trees (2 replications), 23 by 6 trees (1 replication), and 10 by 1, 2 or 3 trees. Most of these samples would, according to present statistical standards, eleven years after this plantation was designed, seem rather inadequate were the comparisons between progenies. But they are more nearly satisfactory for the proposed studies of geographical races, where the differences are larger. In such cases 6, 12 or 18 trees usually constitute samples that are believed to be large enough to show the principal characteristics of the forms concerned. Samples consisting of 1 to 3 trees are obviously below the desired number for fully reliable

averages, but they are by no means so small as to be worthless. In fact, in large tests of tree fruit varieties, involving hundreds of different varieties, it is a common practice to use only 1 or 2 trees of each variety. After thinning, our poorest samples of individual field plots will be in this category, and though of limited value as measures of the growth capacities of the strains concerned, the samples will be very useful for breeding investigations with these forms.

Since there are often two or more field plots per county, the samples of counties will average somewhat better than those for field plots. El Dorado and several other important counties will be represented by 30 or more trees. The unequal allotment of space to the different geographical forms is based on the same principle that has been used so effectively in handling the large number of pine species in the main arboretum. There the land is apportioned roughly according to the importance of the species, much more being given, for example, to species such as ponderosa, caribaea, palustris and radiata than to forms like virginiana, banksiana, leucodermis and albicaulis. Were experimental designs utilized that require equal numbers of trees of all species, it would mean growing much more than we need of the minor ones and an insufficient representation of the important and variable ones. In the same way, it is to our advantage to maintain as large samples as facilities will permit of the rapid-growing and otherwise desirable geographical forms of ponderosa pine. In order to do this, we must keep only relatively small samples of the geographical forms that appear to have the least value in our investigative program.

Since the Institute is interested primarily in the best of each strain or race, especially from the standpoint of future breeding work, two provisions were made in the plantation design to insure the perpetuation after thinning, of not only the best races, but also of the most desirable types from each seed source:

(1) Important localities were represented in the plantation by several progenies, and in these cases the vigorous or otherwise desirable progeny from each locality was, in general, placed in one of the rows designated as permanent, while the normal or weak progenies from the same localities were usually placed in the alternate temporary rows indicated on the map with yellow shading.

(2) Localities of minor importance were represented in the plantation by only one progeny. This was generally placed in a permanent row and was selected as being the most vigorous progeny in the nursery from each of these localities; in this way, the permanent samples of practically all localities were selected as being vigorous for that seed source and are, therefore, comparable.

Probably the most important of the secondary objectives of this investigation is the comparison of the differences in vigor observed in the nursery between different individual seedlings of the same progeny. Each plantation plot of 6 trees consisted, first, of the most vigorous seedling in the nursery plot, then four trees of medium vigor for that progeny, and, last, the smallest seedling in the nursery plot.

The 7-year growth data from this plantation showed that most of the vigorous selections had maintained their lead up to that time. In fact, the seven tallest trees in the entire planting were all ones that were originally selected as vigorous in the nursery, even though this vigorous class constituted only one-sixth of the seedlings outplanted. It is important that these comparisons be carried on to see if the differences maintain themselves. There are at present about 200 of these comparisons, which are very similar to paired tests. After thinning there will be about 100 of them left, and this is abundantly adequate to give very reliable indications of general tendencies and principles. As previously explained, the progenies left will be mostly the most vigorous ones, so there will be available for breeding the most rapid growing individual seedling of the most vigorous progeny of each strain or race.

Already there has been a small amount of flowering and cone production, but conditions are now becoming much too crowded to favor reproductive activity. It is probable that with the additional light that will be available after thinning, nearly all forms will flower within the next five or ten years, and will thus be available for breeding work.

It has been suggested that, instead of systematically removing every other row and leaving the trees intended as permanent in the original carefully worked out plan above described, it might be better to use an irregular selective thinning to save only the best based on an analysis of the 10-year data from this plantation. This idea rests on the entirely erroneous assumption that it is possible to adequately and finally judge the inherent tendencies of different races or progenies of ponderosa pine at the early age of ten years. I feel certain that the decision as to which are, in the long run, the most valuable strains, and the removal of the least valuable ones, should not be based on the first 10 years records, which do not give the ultimate response, but, as originally planned, conditions should be made conducive to continuing the most important features of the test for at least another 10 years in order to obtain more reliable comparisons. Other plantation experiments, such as Weidman's race study of ponderosa pine, have shown that radical and important changes in relative growth rates of different strains may take place between the tenth and twentieth years.

We recently had occasion to show this plantation to Dr. C. F. Korstian. When he had finished going through the planting he remarked that, while the present results are interesting and striking, it is as yet much too early to judge the ultimate response. He considered that it would be exceedingly dangerous to base recommendations for large scale planting on the findings to date, for reversals in relative behavior may occur in later life, as has actually happened with the familiar examples of Scotch pine races in Sweden and Pennsylvania. It would seem that plantation investigations of this kind should be continued for several decades to insure reliable conclusions. Progress reports should be made at periodic intervals, but care should be taken not to base final conclusions on early behavior.

Were this plantation to be thinned out in the near future so as to give more room to some forms than to others, it would invalidate all future growth comparisons. Only by thinning in the scheduled regular manner can reasonably equal opportunity be given to all forms; and only in this way can advantage be taken of the original plan to preserve the best samples of practically all geographical races and other forms of special interest.

In addition to the main objectives covered in the above discussion, this experiment contains a number of other features that are of considerable interest and that are often shown to visitors. Among these may be mentioned the following:

(1) The second generation natural hybrids of ponderosa and Jeffrey showing a segregation of characters according to the parental species (12 trees).

(2) A progeny that demonstrates the inheritance of forking (12 trees).

(3) Nearby plots of the vigorous low elevation form of ponderosa and the slow-growing high elevation form, both from El Dorado county.

(4) Nearby plots of both the 3-needled form from western Montana and the 2-needled form from the eastern part of the same state. Montana is the only state represented in this experiment by both the true P. ponderosa and also by its variety scopulorum.

(5) The most vigorous progeny in the nursery from a fairly high elevation (PP-Eld-3-8), represented by a red pin on our relief model, 18 trees now nearly 20 feet tall.

(6) The smallest of all progenies in the nursery (PPS-Nev-Whi-1-1) - 6 trees now about 3 feet tall.

(7) Progenies of 4 seed-trees selected by the Rocky Mountain Forest Experiment Station for their resistance to Peridermium.

It is worth noting that the plan employed for this plantation was such that all seven of these special features will be preserved after the thinning is completed.

Although most of the best trees are growing in the rows to be saved, there are, naturally, a few fine individual trees that occur in the rows to be removed. It is proposed to save the germ-plasm of the best of these, and of a few geographical strains that will otherwise be lost, by having Mirov propagate them vegetatively, preferably by grafting rather than by the use of cuttings, as the former is at present a more certain way of reproducing pines that are as old as are these trees. In this way practically everything of any value in the plantation will still be available after the thinning operation.

In order to avoid an undue lengthening of this memorandum I will not discuss in detail the resin midge situation in this plantation. This has been fully covered in my recent memorandum on the Institute's policy in regard to insect control, and requires separate action. Suffice it to say here that if the resin midge is not brought under control in this plantation within the next two or three years, it seems likely that practically all growth comparisons will have to be abandoned. In addition, most of the trees will probably become so deformed and stunted that no flowering will occur, and hence breeding work cannot be undertaken. Thinning is urgently needed to facilitate effective resin midge control, but that alone does not warrant the thinning. It is fully justified by the other considerations given above.

SUMMARY

A. Thinning Is Needed Soon:

(1) To prevent loss of slow-growing races and progenies due to suppression.

(2) To enable the continuation of growth comparisons for another ten years under reasonably uniform conditions. (It is too early to draw final conclusions at this time).

(3) To encourage flowering and thus make breeding investigations possible.

(4) To supply more open conditions required for studies of inheritance of branching.

(5) To facilitate insect control.

B. Remaining Material Will Serve The Major Objectives:

(1) Most of the numerous geographical strains or races represented in the nursery and now in the plantation will be preserved.

(2) Most of the best progenies and individual trees thereof will be saved and available for breeding; what few occur in rows to be removed will be preserved by vegetative propagation.

(3) 100 paired tests of vigorous and weak individual seedlings will remain to ascertain by future development the validity of nursery selections for vigor.

RECOMMENDATION

An endeavor should be made to thin out every other row of this plantation during the summer of 1940, before crowding has become so severe as to make ineffective the original design and plans that call for the release of the permanent trees at this stage.

REPRESENTATION OF FIELD UNITS IN NURSERY AND PLANTATION STAGES OF 1939 PROGENY TEST

Number of Field Units Represented (States, counties, field plots or seed-trees)

Species and Field Units	In the Nursery	In plantation before thinning	In Plantation After Thinning (Removing every other row)					
			18 or more trees	12 trees left	6 trees left	1,2 or 3 trees left	TOTAL, 1 to 18 or more trees	0 trees left
P. ponderosa								
States	6	6	2	1		2	5	1
Counties	42	36	6	7	8	9	30	7
Field Plots	101	57	8	15	11	8	42	15
Seed-trees	674	86	2	23	20	9	54	32
P.p. scopulorum								
States	8	8	1	5	1	1	8	0
Counties	12	12		5	4	1	10	2
Field Plots	16	14		5	8	1	12	2
Seed-trees	41	18		2	10	1	13	5
P. jeffreyi								
States	2	2	1		1		2	0
Counties	8	8			4	1	5	3
Field Plots	11	9			4	1	5	4
Seed-trees	50	11			4	1	5	6
TOTALS FOR ABOVE THREE FORMS*								
States	14	14	3	6	2	3	13	1
Counties	57	52	6	12	15	11	42	10
Field Plots	128	80	8	18	23	10	59	21
Seed-trees	765	115	2	25	34	11	72	43

*Some states or counties are represented by both P. ponderosa and P. jeffreyi, or by both P. ponderosa and P.p. scopulorum. In these totals all such duplication has been eliminated and the figures now show the actual number of states and counties represented by all forms. Some of the totals are, therefore, slightly less than the sum of the items.